DoD's WAR ON HAZARDOUS WASTE

Measuring Hazardous Waste Reduction

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Executive Summary

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Measuring Hazardous Waste Reduction

The Department of Defense has made a commitment to reduce the amount of hazardous waste generated at maintenance depots to 50 percent of 1985 levels by 1992. However, two major conditions hamper its effort to assess progress to date. First, DoD believes that the availability and accuracy of waste generation data are limited, and second, DoD's maintenance workload has declined, and DoD is not able to determine with certainty whether reported decreases in hazardous waste generation merely reflect that decline. LMI was tasked to assess the feasibility of achieving more effective measurement without imposing additional burdens on DoD installations and to determine whether the resulting data could be adjusted to reflect changing workloads.

We studied current reporting processes for workload and waste generation and visited a major Army depot to verify our findings. We conclude that DoD collects enough data to support both hazardous waste measurement system and appropriate workload-based adjustments. Waste should be measured by weight and indexed — that is, adjusted to account for workload changes — based on direct-labor hours. However, the data definitions and collection cycles need to be made consistent across all DoD activities.

We found that the data for a single installation can fluctuate widely from year to year as a result of large disposals, transportation contract lapses, or regulatory interventions, among other causes. We conclude that focusing on changes to the waste patterns over a short term for a single installation would be misleading.

We recommend that the Office of the Deputy Assistant Secretary of Defense (Environment) should take the following actions:

- Establish precise definitions and consistent data collection practices across all DoD activities

- Track hazardous waste reductions by weight and index the reduction data to account for workload shifts

- Consolidate waste and workload data for multiple installations in assessing year-to-year progress, and avoid attempting to evaluate each individual installation's progress over a short period of time.

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CHAPTER 1

MEASURING REDUCTION

BACKGROUND

The Department of Defense has made a commitment to reduce the hazardous waste generated at maintenance depots to 50 percent of 1985 levels by 1992. Its goal is to reduce the hazardous waste even more, but its effort is being hampered by two conditions.

First, DoD has incomplete historic data on hazardous waste. Current hazardous waste data are maintained by the Defense Reutilization and Marketing Service (DRMS) and are considered to be fairly accurate, but the data for years prior to 1988 are considered unreliable. In addition, no information is available on the amount of waste generated by installations and disposed through local treatment facilities or contracts without DRMS involvement. While each installation must maintain records of such transactions, those data address only waste disposal. Figures on waste generation have not been maintained in the past, and DoD has not defined a standard method for collecting such data.

Second, after years of consistent growth, DoD activity is expected to decline over the next few years. Thus, we can expect a decline in output of hazardous waste merely as a result of lower activity levels. To meet its reduction commitment, however, DoD must demonstrate not merely a decline in hazardous waste but also a real decrease as a result of improvements to processes or recycling. Thus, it needs a method for normalizing the waste measurement to account for changing operating tempo. Such normalization can be achieved through an "index" system.

The Logistics Management Institute (LMI) was tasked to review DoD's hazardous waste reduction effort to determine whether an index could be developed from generally available data without placing new reporting burdens on installation staffs and whether the index could be reconstructed back to 1985. As a first step, we participated in a concurrent effort by the Joint Logistics Commanders to review the hazardous waste minimization performance of maintenance depots. This report records our findings and conclusions based on a general overview of available data

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and an in-depth review of the site-specific data at the Letterkenny Army Depot (LEAD) in Chambersburg, Pa. Future reports will amplify our findings as additional data become available and as the depots of other Military Services are examined in more detail.

DoD HAZARDOUS WASTE REDUCTION INDEX

The hazardous waste reduction index demonstrates DoD-wide progress in meeting reduction goals. As a minimum, therefore, DoD must sum all the waste generation and adjust for operating tempo. To do so, it must have summary data in units of measure; separate indices compiled by the Military Services cannot be combined meaningfully.

For instance, if two Services, respectively, report indices of 1,200 kg and 1,800 kg of waste per item produced, we cannot say that the DoD total is the average (i.e., 1,500 kg per item produced). The correct, or weighted, average depends on the number of items produced by each Service. Thus, to calculate the overall DoD statistic, we must know the total weight of waste and the total number of items produced.

Quantity of Waste Measures

Any hazardous waste index must be based on hazardous waste quantities. Furthermore, all the measurements must use a common scale; we cannot mix kilograms and gallons of waste, for example. Since environmental laws require that hazardous waste manifests be provided in kilograms, we recommend DoD use that measure for all waste issues.

More important, we must resolve whether all waste products are equally significant. Is the production of 1,000 kg of dioxin worse than the production of 1,000 kg of polychlorinated biphenyl (PCB)? If an inequality exists, we must assign a relative weight to each type of waste; since several hundreds of waste types have been identified, such an approach could quickly become both cumbersome and arbitrary. At the DoD level, the stated goal is to reduce *all* waste by 50 percent. While progress in specific waste categories may vary, DoD has not established goals for each category. Our initial approach, therefore, is to avoid discrimination among forms of waste.

At present, since waste generation data are not being collected, we have to use waste disposal data as a proxy. While this approach ignores waste recycling efforts within the depots themselves, it does measure the net threat to the environment outside the depots. Subsequently in this report, w · discuss some of the weaknesses of disposal-based measurement.

Operating Tempo Measures

One measure of operating tempo is the level of effort at the depots. However, since the nature of the work at maintenance depots varies over time, we have little data on the levels of effort required to sustain various activities. A recent General Accounting Office (GAO) report on hazardous waste indicates that depots have difficulty adjusting the size of their work force to reflect changing workloads. Thus, the gross measurement of labor hours does not truly reflect workload. However, the depots generally operate in a job-order environment. At least nominally, all labor and materials charged to a piece of work must have been used in that work. While some discrepancies in accounting may exist, these "direct-charge" measures should generally describe the amount of work actually done.

Another possible measure of work is the amount of materials expended. We found that for most depots, material costs remain consistent as a proportion of direct labor costs. The proportion of materials to labor should not vary significantly within a process; a labor-intensive process should remain that way regardless of the number of items produced. Thus, in any comparison of similar processes, the number of labor hours should adequately reflect the amount of work done.

As an alternative to hour-based data, one could collect the costs of labor and materials, even combining them if desired. However, labor-hour and raw-materials costs both differ in different years and different regions, and the incidence of cost increases is not uniform. Adjusting for inflation and regional cost differences opens a range of arguments over the proper baseline rate and method of adjustment.

Figure 1-1 shows the potential output if such data (kilograms of hazardous waste per labor hour) were generated over time. The DoD-level data show overall trends clearly. If required, the relative effectiveness of individual installations in reducing waste can be tracked in much the same way. The actual performance of single installations can be identified. While we always have a tendency to compare data points, such a comparison is particularly inappropriate in the case of depots.

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The total number of depots is quite small, rendering serious statistical manipulation impractical, and the workload varies widely among installations because of the type of equipment maintained and the type of work done. In Figure 1-1, we show the tracking of an installation's success (Depot A) in waste reduction and another installation's lack of success (Depot B). Following an installation's success over time may be reasonable, but as the figure shows, one-time comparisons between installations — such as blaming Depot A for its "higher" waste rate — may be inappropriate.
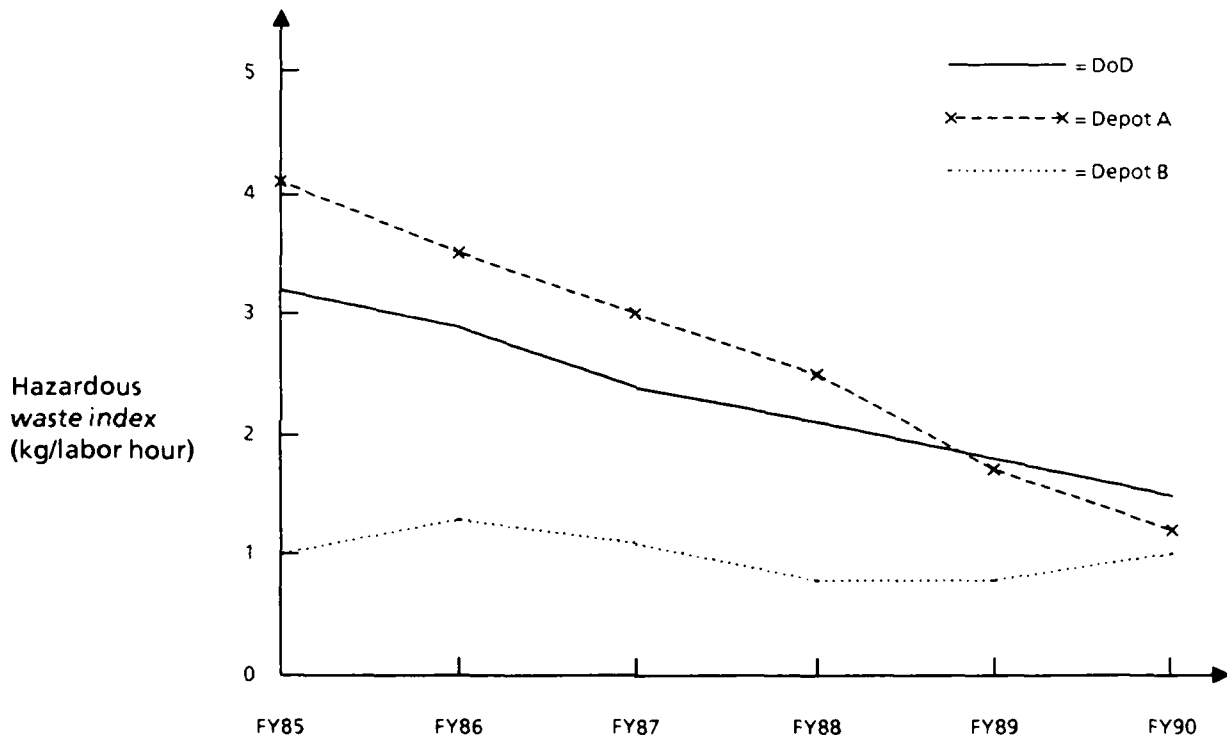
FIG. 1-1. PROGRESS OVER TIME
(Notional data)

As a final note on workload measurement, we should comment on the impact of contracting some work to civilian facilities. If DoD shifted all its production work to off-base contractors, its hazardous waste liability would be minimal and since private-sector contractors are often under much tighter regulatory control, the potential for spills, etc., could be reduced; thus, an index should not penalize DoD for hazardous waste generated and disposed of by depot contractors off base.

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SELECTING A LEVEL OF DETAIL

First-Level Index

Hazardous waste is generated through production processes at maintenance depots. Painting and plating processes, for example, generate waste; if production processes were stopped or modified, waste could be reduced. Figure 1-2 shows a simplified depot in which a piece of equipment enters a maintenance process and, through the application of labor and materials, emerges as repaired equipment, leaving some degree of waste as a by-product. The simplest and most fundamental waste-to-workload index is that shown in Figure 1-2. We call it the first-level index, indicating that a minimal amount of data and detail are required in its construction. The problem with a first-level approach is that in its simplicity it ignores key factors; we show subsequently that the real data collected from a depot can be completely misleading when subjected to first-level indexing.
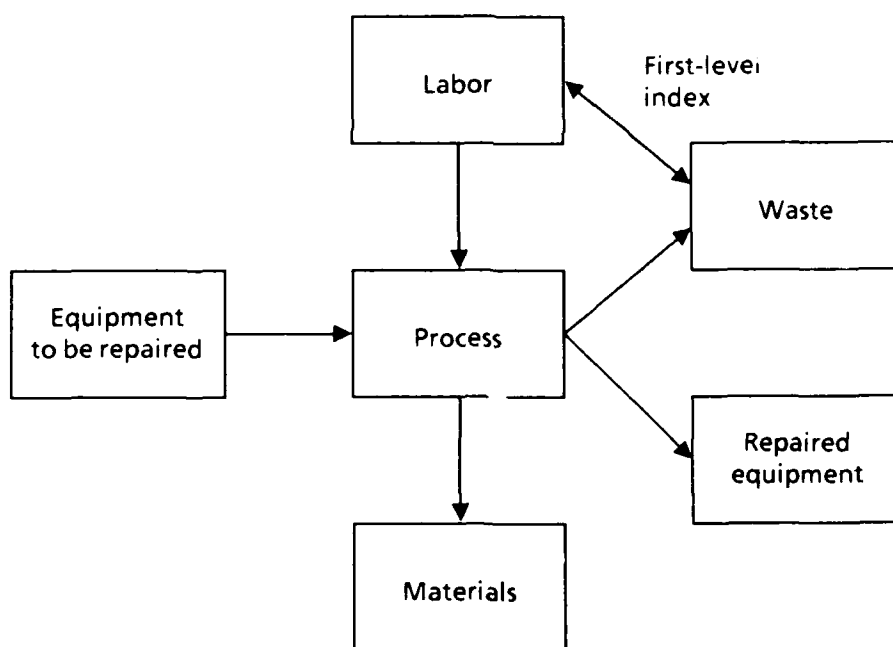
FIG. 1-2. GENERIC PRODUCTION PROCESS

Reality is more complex. In the still-simplified but more-detailed view of a depot depicted in Figure 1-3, we see a single item of equipment entering the maintenance process, passing through three specific processes (which have different waste generation profiles), and emerging as repaired equipment with a waste

by-product. The first-level index, as shown, still relates the total waste to the total workload.
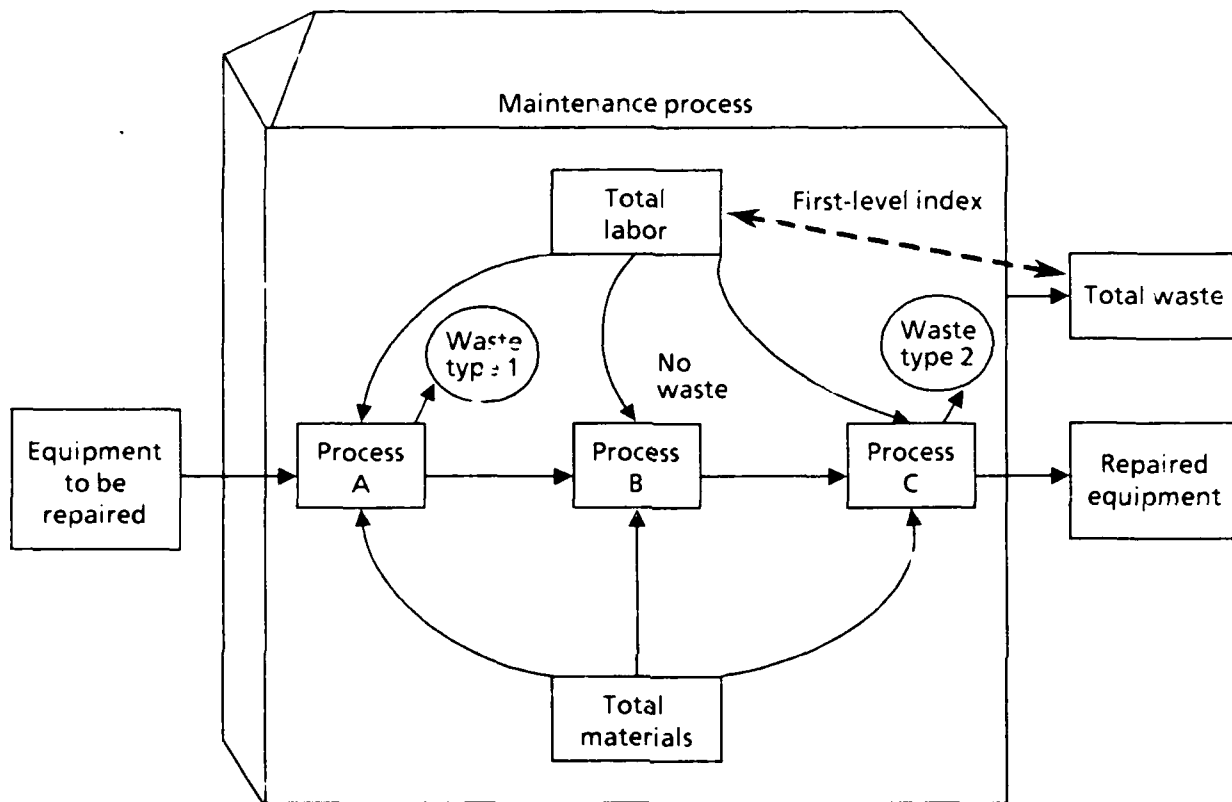
FIG. 1-3. PROCESS FLOW AND ASSOCIATED DATA

However, two dissimilar products (for instance, jet engines and cannon tubes) may both use plating, but the volume of waste generated from the process may be greatly different for the two types of equipment. In addition, the type of waste generated may vary from one process to another: plating and battery repair may generate totally different forms of hazardous waste. Three variables, then, must be considered in analyzing the generation of hazardous waste: the equipment being worked on, the processes being employed, and the types of waste being generated.

Second-Level Index

A second level of detail could be added by considering the potential for varying the workload in terms of the types of equipment handled, the process to which that

equipment is subjected, and the ˈ„pes of waste generated by those processes. Figure 1-4 summarizes that approach.

First-level index

Labor

Total waste

Equipment → Processes → Wastes

Second-level index

Second-level index
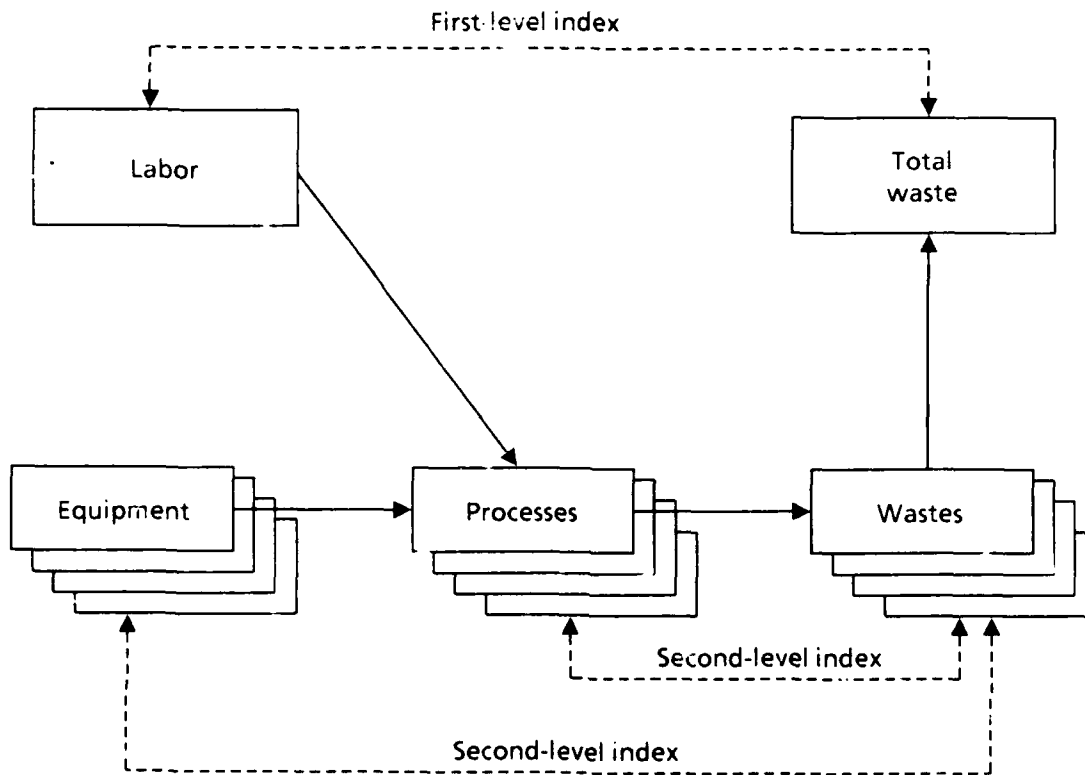
FIG. 1-4. INDEX LEVELS

Attempts to subdivide the DoD index simply result in a more complex, less comprehensible number. That inevitably leads to disagreement over the interpretation of the index or over the accuracy of the data used in computing it. At a DoD level, therefore, the objective is to adopt a simple, clear index that aims directly at representing diminishing waste with a minimum of "interpretation." In the event that the index does not represent the facts, more detail must be added. In our initial data collection effort, it appears that second-level details may be needed. It may be possible to weight the items of data and combine them back into a single index; that determination cannot be made without additional research.

Data Sources

DoD prefers to avoid the creation of another data collection requirement. In the case of hazardous waste, we have already noted that generation data are largely unavailable, especially for past years. Workload and disposal data are more readily available, as shown in Table 1-1, and disposal data address the question of reducing hazardous waste disposals directly.

TABLE 1-1

HAZARDOUS WASTE INDEX DATA SOURCES

Data items	Method of recording	Highest location
Equipment	1397 report	OSD
Total labor	1397 report	OSD
Total materials	Cost – 1397 report	OSD
	Items – supply records	Depot
Total waste	Disposal – DRMS report	DRMS
	All types – DESR	AMC
Process waste	HAZMIN report (category)	DESCOM
Process labor	Operation code data	Depot
	Cost code basis	DESCOM
	HAZMIN category basis	N/A
	Equipment basis	OSD
Process materials	Cost code basis	Depot
	Equipment basis	OSD

Note: DESR = Defense Environmental Status Report; AMC = U.S. Army Materiel Command; HAZMIN = Hazardous Waste Minimization; DESCOM = U.S. Army Depot System Command; N/A = not applicable

Between budgetary data required by DoD Directive (DoDD) 7220.29H, *Department of Defense Depot Maintenance Support Cost Accounting and Production Reporting Handbook,* and waste data required by the Resource Conservation and Recovery Act (RCRA), most of the essential items in arriving at first- or second-level indices are available to the depots today. Not all are readily collected by OSD, but their collection is possible with little added burden on the depots. The remaining important question is the degree of accuracy of the data.

CHAPTER 2

FIELD TESTING THE INDEX

We visited the Letterkenny Army Depot in July 1990 to confirm the validity of the data sources available to DoD with no further collection effort on the part of the installations and to ensure the indices reflected the real situation.

FIRST-LEVEL INDICES

Prior to the trip, we obtained workload data from OSD (as prescribed for all maintenance depots under DoDD 7220.29H) for FY85 through FY89. In Table 2-1, we compare those data with the depot's records for the same period. The discrepancies arise because DoD and the depot used a different definition of data. DoD data are based on work programs closed out during a given fiscal year; many of those programs began in other years, and in many cases, ongoing work was done on projects that were not yet closed out. The depot's reporting system, however, indicates current-year efforts. The parallelism and dissimilarities of the data are illustrated in Table 2-2. Despite the different collection periods, when the work is accumulated, as shown, the differences are eliminated.

TABLE 2-1

LETTERKENNY ARMY DEPOT WORKLOAD

Fiscal year	DoD data (labor hours)	Depot data (labor hours)	Percent difference
85	2,116,000	2,607,000	+ 23
86	2,573,000	2,535,000	− 1
87	3,032,000	2,030,000	− 33
88	2,124,000	1,920,000	− 10
89	1,843,000	2,106,000	+ 14
Total	11,688,000	11,198,000	− 4

TABLE 2-2

LABOR-YEAR ALLOCATION

(Notional data)

Notional project	Fiscal year						Total work	Comple- tion year
	Earlier	85	86	87	88	Later		
A	2.0	0.1	–	–	–	–	2.1	85
B	–	1.2	0.7	–	–	–	1.9	86
C	–	0.7	1.3	2.0	–	–	4.0	87
D	–	–	–	–	2.0	2.0	4.0	Later
Actual work	2.0	2.0	2.0	2.0	2.0	2.0	12.0	
DoD work reported	0	2.1	1.9	4.0	0	4.0	12.0	

In addition, we contacted DRMS, which is DoD's broker for the vast majority of hazardous waste disposal. DRMS has recently implemented an automated data system for tracking disposal contracts beginning with those awarded in FY89. However, DRMS has records for earlier years in raw paper form, and it estimated that it would take weeks to extract the data for even one installation. We conclude that waste data are available to DoD for FY89 and forward, but historical data may not be worth the trouble to collect through DRMS; installation records, even if inaccurate, may be adequate for the task.

At LEAD, we were able to obtain waste management records for FY85, FY87, and FY88. That information is displayed in Table 2-3. Waste data for the same period provided by U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) revealed the same inconsistencies in waste generation patterns and additionally were not easily reconciled to the depot records, as shown in Table 2-3.

A comparison of the workload data and waste data (in essence, the proposed first-level index) for the 3 years for which data were available revealed major inconsistencies with the basic idea that if the workload decreased and waste-reduction efforts were expended, waste generation should decrease. That comparison

is displayed in Table 2-4. Resolution of the apparent inconsistencies led us into discussions of second-level index issues.

TABLE 2-3

WASTE GENERATION DATA

(Kilograms)

	Fiscal year				
	85	86	87	88	Cumulative
Depot data USATHAMA data	1,772,100 695,600	N/A 1,374,000	3,290,000 2,933,000	1,613,255 1,218,000	6,675,355[a] 6,220,600
Percent difference	+ 155	N/A	+ 12	+ 32	+ 7[a]

[a] Note that depot figures for 3 years are higher than USATHAMA figures for 4 years.

TABLE 2-4

FIRST-LEVEL INDEX FOR LETTERKENNY ARMY DEPOT

	Fiscal year					
	85	86	87	88	Cumulative 85–88	89
Waste (kg)[a] Workload (hours)[b] Index	695,600 2,607,000 0.27	1,374,000 2,535,000 0.54	2,993,000 2,030,000 1.47	1,218,000 1,920,000 0.63	6,220,600 9,092,000 0.68	5,500,000 2,106,000 2.61
Percent change, waste	–	+ 98	+ 117	– 59		+ 351
Percent change, workload	–	– 2	– 20	– 5	–	+ 10
Percent change, index	–	+ 100	+ 172	– 57	–	+ 314

[a] USATHAMA data.
[b] LEAD data

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SECOND-LEVEL INDICES

The purpose of second-level indices is to provide a more detailed description of the first-level index, thereby clarifying apparent inconsistencies. Initial discussions at LEAD suggested that the discrepancies in waste-to-workload ratios may have been attributable to several factors. First, in some fiscal years, the depot shifted its major emphasis from ordnance repair to a very extensive truck refurbishment program; this change in emphasis affected both the type of work done and the nature of the waste generated, two of the potential second-level indices noted earlier. Next, as a result of shelf life in some cases and replacement of facilities in others, the depot was required to drain large vats (thousands of kilograms) of hazardous material (such as plating solution), which ordinarily simply remains in place and is used in the industrial process rather than being termed "waste." Finally, the regulatory process now designates as hazardous some forms of waste that were previously not considered as such. The installation also undergoes changes in the form of new equipment, new processes, etc., some of which generate more or less waste.

Changes in Equipment Categories

Through DoDD 7220.29H, OSD collects information on specific commodities (specific components of specific pieces of equipment), summarized by general equipment categories. In addition, the depot's work management system tracks work by job orders, which appear initially to track back to those commodities. Thus, we should be able to identify specific workloads against specific commodities. However, the LEAD staff insists that this means of collecting data is impractical and unrealistic.

It is impractical because the degree of work to be done on a major end item such as a truck or a tank varies tremendously from one job order to the next. The variance is less on smaller components, such as engines and transmissions, but at that level of detail the number of categories (in the hundreds, depending on the depot and the end item) approaches the number of data points and makes analysis meaningless. It is unrealistic because work on an end item is charged either against the end item or its components depending on the specific work being done at the moment. LEAD's staff has worked on a similar approach for internal management in the past and has not reached a satisfactory way of measuring work by components. However, since (as we

discuss later) no other workload measure appears to predict waste generation effectively, this measure may have to be investigated in more detail.

Changes in Work Done

The significant differences in equipment repaired, and the changes in the wastes produced by industrial processes over time, shown in Table 2-5, led us to consider whether we could identify specific types of work as waste producing and whether measurement of those types of work would generate a more consistent normalization. As part of its work management system, the depot tracks activities within generic classes called operation codes (OPCODEs); those codes are established by the U.S. Army Depot System Command (DESCOM) and are uniform for all Army depots. These codes cross equipment lines and attempt to describe the specific work done.

Notice the value of this data disaggregation. We can see immediately that LEAD's major problems, both in volume of waste and in increasing waste, are in painting and in industrial waste sludges. With this level of detail, LEAD has been able to focus its attention in FY89 on those two areas through initiatives such as a sludge compactor and alternative methods of depainting. OSD should be able to do the same thing on a DoD-wide basis.

LEAD attempted to provide a summary of the work done by OPCODE over a specific period so that we could compare waste-producing work with the total direct labor hours charged during the same period. That effort, however, was beyond the capacity of the Standard Depot System (SDS). The LEAD staff believes that in general its waste-producing activities are also the major industrial activities (at around 65 percent of the total direct labor hours) and will therefore show high correlation with labor hours. In that case, the overall direct labor-hour total (readily available through DoDD 7220.29H) is an effective work measure for maintenance depots.

Process and Waste Changes

One of the biggest problems with data collection in the environmental arena is the continuing redefinition of the baseline. As a significant example, regulations have defined used oil as hazardous if it contains certain levels of substances. Beginning in FY91, however, the acceptable levels of those substances is reduced

TABLE 2-5

WASTE STREAMS OVER TIME

(Kilograms)

Source	Type[a]	Fiscal year		
		85	87	88
Plating	2	23,789	147,200	1,281
	4	83,830	–	–
Painting	1	35,695	224,500	123,033
	2	11,839	19,300	116,351
	4	408,351	697,400	504,707
	5	571	–	–
Degreasing	1	–	12,500	32,242
	5	237,764	173,700	38,767
Battery	2	5,098	7,800	8,956
Photo	2	700	–	–
Industrial waste sludge	5	289,842	1,705,800	521,523
Wash racks	4	3,125	800	–
Ammunition	3	115,086	23,900	37,931
Electroplating	All	17,192	126,000	34,455
Miscellaneous	All	67,110	50,200	27,254

[a] Classes of waste have been aggregated by the Army into "waste types" within its process categories.

sharply. LEAD believes that many of its current oil wastes contain minute levels of those substances and, therefore, will contribute to a large increase in "hazardous waste" even though the process has not changed at all. We can readily isolate the newly regulated substances, and DoD could continue in its assessment of goal accomplishment by discounting them; in the case of waste oil, however, such treatment is not possible. Since the history of waste generation per process is so inconsistent (as shown in Table 2-5), the alternative of assuming that a certain proportion of an increased quantity is due to more stringent regulations is difficult to support.

New processes or one-time events offer another source of anomalies. Because it invested in a sludge compactor, LEAD was able to reduce its output of sludge-related waste from over 1 million kg of sludge (most of which was actually water) in 1987 to a few thousand kilograms of densely compacted dry "sludge cakes" in 1988. The actual amount of hazardous material in each case is considered to be similar. Should DoD then take credit for a 25-fold decrease in the weight of hazardous waste, knowing that the amount of actual hazardous substance itself remains essentially unaltered and, in fact, probably increased? To illustrate the reverse example, LEAD closed and emptied its sludge lagoons in 1989, resulting in the disposal of over 20 million tons of lagoon waste — a quantity equal to the waste load of the previous 10 years! Should DoD reprimand itself for an increase in "waste" when in fact a large volume of material was removed from a potentially hazardous configuration?

INTERMITTENT WASTES

The OPCODE data should allow us to identify the effect of certain operations (such as painting) on the paint waste stream. However, some operations such as plating result in waste disposals intermittently and almost independent of the work rate although to some degree plating tanks would not be filled if there was no expectation of work. For such functions, a longer term view of workload with a pro-rationing of the waste on an annual basis may be appropriate; another alternative is to consider those processes or waste streams as processes separate from continuous-waste processes.

We considered attempting to portray these operations based on the materials that went *into* the waste-producing process. However, treating the input as waste would ignore LEAD's success to date in replacing heavy waste-generating products (some types of paint, for instance) with less-hazardous substances that are disposable as nonhazardous wastes. Clearly, such efficiencies are critical to the waste minimization process and must not be erased from the accounting. An approach discussed with LEAD staff was to account for hazardous material issued by national stock number (NSN); the initial assessment was that the data collection effort would be extremely demanding.

Part of the problem here is the failure in the past to consider long-term waste liabilities in DoD's inventory of waste. Plating tanks and sludge lagoons may have to be considered as "stored waste" to make the index meaningful; without such a

concept, when disposals from these de facto storage facilities occur, we see large increases in waste disposals with no accompanying changes in workloads. Indeed, the real difficulty is that until very recently waste generation data (as opposed to disposal data) have not been available at any level. LEAD is moving aggressively toward a source-based generation data system, but that system is not yet complete and may not be standardized. The Corps of Engineers Research Laboratory (CERL) has been working with the Corpus Christi Army Depot on a similar initiative. Neither of those systems is fully operational, and neither is intended for reporting upward. DoD should monitor the progress of those initiatives and decide whether a standard process with reporting capability is worth the extra investment that would be required.

SMOOTHING THE INDEX

Clearly for a single installation, year-to-year comparisons are invitations to debate. We found that the existing data contained many exemptions from DESR reporting; those exemptions, along with the definition of what must be reported, need to be established uniformly for all of DoD. Even when definitional discrepancies are eliminated, the annual data at a single installation are highly sensitive to unique events. Those descriptions, while different from year to year, occur regularly enough that a simple waste-to-workload index based on current data seems to require case histories on each data point in order to understand the index, and DoD does not need an index that must be defended. The need for case-by-case caveats will simply lead to a further loss of credibility for DoD's environmental efforts. The earlier discussion does, however, suggest two possibilities: the index may be restored by the volume of data to be found at many depots despite its apparent contradiction at a single site, or the index may take on more meaning when applied over time.

Smoothing by Volume

Overall, DoD data may provide relief for the year-to-year inconsistencies in data shown by any one depot. However, the total number of installations is small. As we look at the data from the 38 depots of all Services, we will establish whether sufficient data are accumulated over a year to override individual anomalies.

For this paper, we have taken randomly generated data for a set of 26 observations in four time periods to model a depot system over time. In this random generation, the range of possible outcomes is reduced in each year,

representing actual progress toward reduction goals, with workloads varying around a constant level. As can be seen from the net result displayed in Table 2-6, while several individual "depots" show extreme anomalies, the overall waste product does drop significantly, but in this random run, the overall goal is not quite met despite setting up conditions so that it should be.

Smoothing Over Time

Lapses in DRMS's disposal contract process led to a stockpiling of waste in some quarters (or years) with subsequent disproportionate peaks of activity once disposal capability was restored. We concluded that to account for this, we might have to accumulate all work done and all waste generated, thus forming a rolling-average type of index. The result of that process for LEAD was displayed in Tables 2-3, 2-4, and 2-5. Table 2-7 shows the result of such a process for the depots used in our computer model.

In Table 2-7, the total-work and total-waste figures are taken from the totals in Table 2-6. The first-level index is simply the total waste divided by the total workload.

We have established an arbitrary set of goals leading to a 50 percent reduction by the fourth year. Since the workload varies, we cannot say that the total amount of waste must be decreased by 50 percent — it must be adjusted for workload. That adjustment is made by restating the goal as "reduce the current index by 50 percent," as shown in the "index goal" lines in Table 2-7.

Because discrepancies in the data may force us to aggregate data cumulatively rather than year by year, we considered the use of a cumulative index. A cumulative index would require knowledge of the intended path of reductions and of year by year progress. First, we convert the annual index goals into waste goals as shown in the following equation:

$$Waste\,goals = Index\,goal \left(\frac{tons}{ly} \right) x\,waste\,performed\,(ly)$$

where ly is labor years. Notice that 50 percent of the original waste level would have been 1,106 × 50 percent = 553 tons, but since our workload is lower, the acceptable waste level must also decrease to 456 tons.

TABLE 2-6

SIMULATION OF DEPOT WASTE AND WORKLOAD

Depot	Work level[a]				Waste level[b]			
	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4
A	40	30	30	33	70	4	38	16
B	7	5	5	5	16	11	5	1
C	11	8	8	12	5	21	9	5
D	35	26	26	26	31	62	26	8
E	8	6	6	6	2	13	1	1
F	89	105	67	70	119	153	59	35
G	11	10	9	12	8	3	3	12
H	5	4	4	6	11	1	6	5
I	99	74	74	74	217	28	85	18
J	48	43	36	36	15	17	50	27
K	1	1	1	2	1	2	0	1
L	46	44	34	38	8	90	70	45
M	96	80	72	72	56	18	35	25
N	6	5	5	5	14	2	9	7
O	55	41	54	65	103	34	3	18
P	58	47	46	43	69	53	55	58
Q	59	45	45	64	53	15	7	58
R	12	12	9	12	8	10	4	3
S	44	39	52	33	34	23	5	27
T	52	45	41	39	113	10	77	22
U	25	28	19	19	0	47	0	20
V	91	70	68	68	28	54	121	62
W	28	21	27	21	26	15	44	12
X	50	37	37	42	10	20	56	41
Y	25	25	19	19	14	43	9	9
Z	55	63	65	55	76	47	10	4
Total	**1,056**	**914**	**859**	**877**	**1,107**	**796**	**787**	**540**

[a] 100 = maximum initial workload; out-years: 75 – 120 percent of current.

[b] Maximum waste in each year = 250, 213, 163, and 113, respectively, in proportion to Year 1 workload.

TABLE 2-7

INDICES FOR SIMULATED DEPOTS

Data	Year 1	Year 2	Year 3	Year 4
Annual				
. Total waste	1,107	796	787	540
Total work	1,056	914	859	877
First-level index	1.05	0.87	0.92	0.62
Goal	–	– 10%	– 20%	– 50%
Index goal	1.05	0.94	0.84	0.52
Cumulative				
Waste goal	1,107	859	721	456
Cumulative waste goal	1,107	1,965	2,686	3,142
Cumulative workload	1,056	1,970	2,829	3,706
Cumulative index goal	1.05	1.00	0.95	0.85
Cumulative waste	1,107	1,902	2,689	3,229
Cumulative index	1.05	0.96	0.95	0.87

The cumulative workload line sums the workload for all previous years, and the cumulative index goal notes what the index would be for a year if the cumulative waste goals are met for the expected workload (i.e., cumulative waste goals divided by workload).

The actual (achieved) index is calculated similarly by dividing the cumulative actual waste by the workload. Graphs of the notional depots' progress (Figures 2-1 and 2-2) may help to illustrate this set of calculations.

Such a cumulative (or rolling) index has one fundamental drawback: it is difficult to interpret. For instance, a 50 percent reduction goal is achieved by reducing an index from 1.00 to perhaps 0.7 (the cumulative total of waste) rather than to 0.5 (measuring current year waste streams only). Current waste goals must be translated into the rolling index to be measurable. An example of this process is portrayed in Table 2-7; an annual index of 1.05 must be reduced to 0.52, requiring a reduction in the cumulative index to 0.85. Although the Year 4 annual index realized was 0.62 (missing the goal by 20 percent), the cumulative index of 0.87 shows

a miss of only 2 percent on the goal, giving credit for the large reductions in Year 2 that are missed by focussing on the year-to-year index.
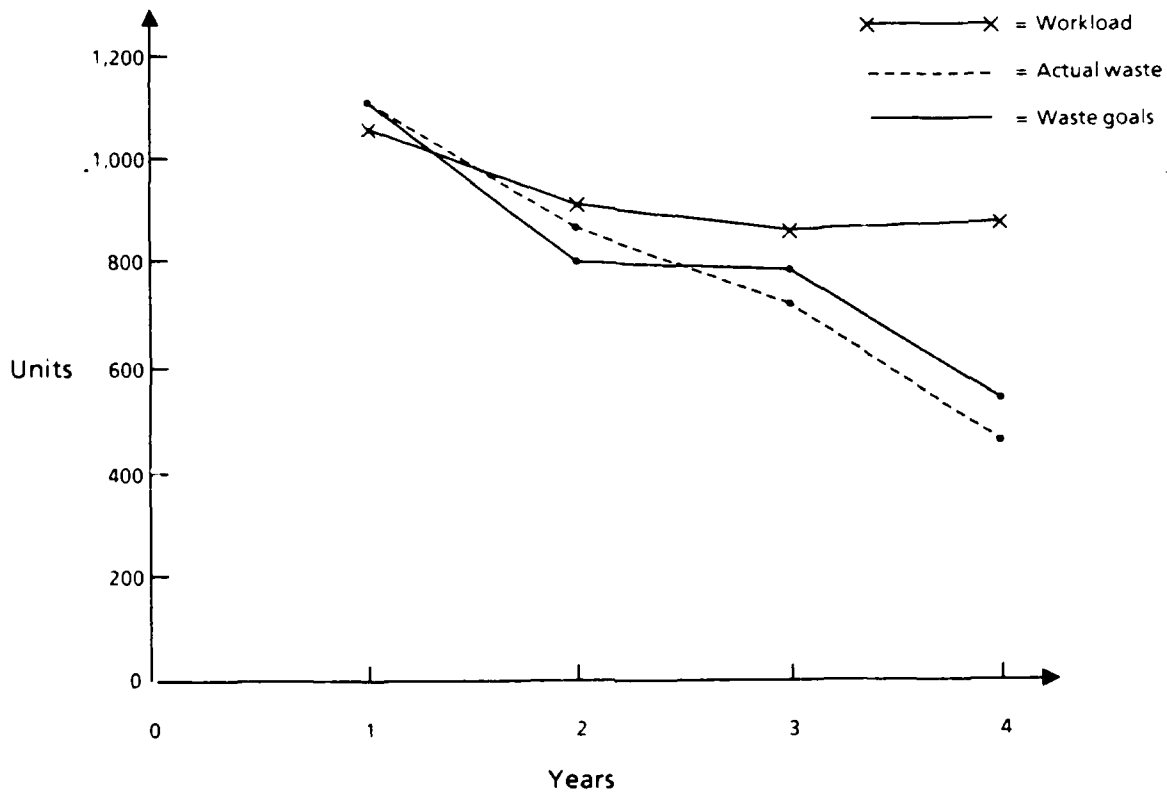
FIG. 2-1. DATA CONTRIBUTING TO A FIRST-LEVEL INDEX
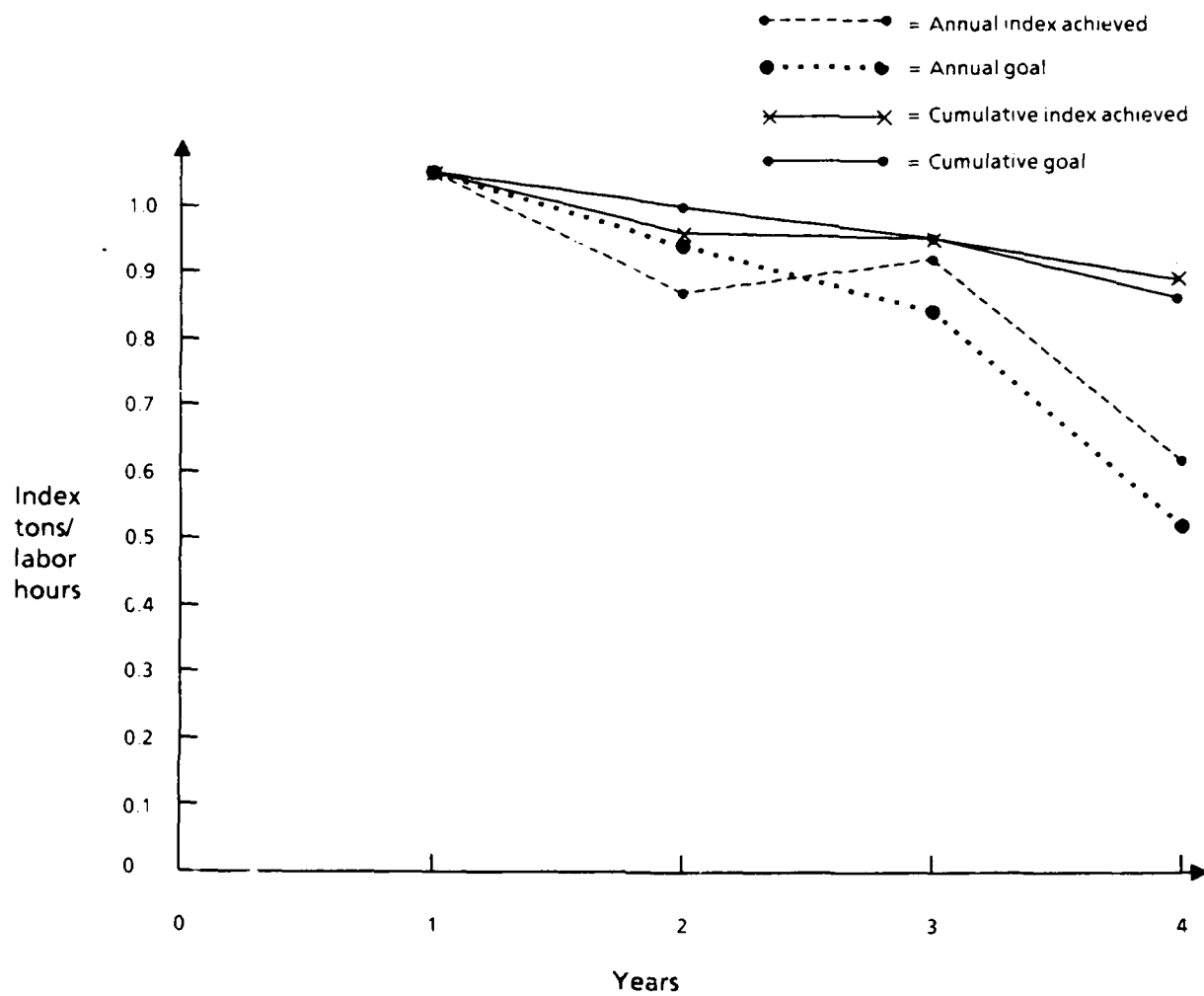
(Annual progress, hypothetical data)

FIG. 2-2. ANNUAL AND CUMULATIVE INDEX COMPARISON

(Hypothetical data)

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CHAPTER 3

INITIAL CONCLUSIONS

While we have some data for monitoring progress in hazardous waste reduction, those data are incomplete. The Services' major commands could provide more detailed data without placing a collection burden on the depots directly. DoD has only recently initiated effective hazardous waste measurements, and thus establishment of the true 1985 baseline will be impossible. Therefore, we recommend that OSD ignore its earlier goal and re-establish annual goals for reduction from an FY90 baseline.

At present, a total weight of waste appears to be the only single consistent measure of waste streams. We expect that the Air Force practice of including sewage treatment plant waste will be either discontinued for the purposes of waste measurement or that such a measurement will be required of all Services. For the Army, the total weight of waste is easily available through the HAZMIN report and confirmed through DRMS contract records; future trips will reveal whether similar reporting systems are in place in other Services.

We anticipate that workload can be measured in direct labor hours. The measurement of that criterion is quite precise, especially in comparison with the difficulties in measuring waste streams. A cumulative measure will probably be required.

The conclusion from the above findings is that a first-level index can be developed, but its utility is still open to question. Further visits and data tests will be required to determine whether the number of installations is sufficient to overcome single-year anomalies at given depots. In either case, OSD must be extremely wary of trying to make comparisons between installations based on performance in any given year.

In the end, if a consistent overall measure cannot be developed, several indices to measure progress by individual waste categories may be the only effective solution. That would require definition of a suitable categorization system and establishing an effective measure of progress in each category. We again caution

against attempts to track a single installation's progress based on only a few years' data and in the absence of further disaggregation of the waste streams. We offer that caution because of the very strong effect of intermittent discharges. We further caution against comparing the indices of two separate installations at any point in time because of the very great differences in the activities occurring at different installations.